Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

2022
2023

ACDS YEAR IN REVIEW

AUSTRALIAN CLINICAL DOSIMETRY SERVICE

WELCOME TO THE ACDS 2022–23

YEAR IN REVIEW

A publication of the Australian Clinical Dosimetry Service (ACDS)

Throughout the year the ACDS continued to provide a comprehensive dosimetry audit service to radiotherapy facilities across Australia and New Zealand. As part of the Federal Government's Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), ACDS fully aligns with the Agency's initiative to promote the safe and effective use of medical radiation.

In the year ACDS delivered a full program of 170 dosimetry audits, including 63 remote audits and 107 onsite audits covering the range of radiotherapy treatment units and treatment techniques. Of particular note, ACDS continued to support stereotactic ablative body radiotherapy (SABR) techniques in radiotherapy facilities across Australia and New Zealand with SABR audits as an integral part of ACDS's scheduled Level III audit service. During the year, 38 Level III audits were conducted that included a component of SABR cases. These audits provide confidence in the SABR technique for separate treatment cases including soft tissue, spine and lung.

Audits of stereotactic radiosurgery (SRS) and kilovoltage X-ray therapy matured to live audits from 1 July 2022. Seven live SRS audits were conducted in the year as well as two live Level Ib kilovoltage x-ray audits. ACDS recognises that uptake of these audits has been low and undertakes to further promote awareness of these new audits to radiotherapy facilities.

International engagement continued for the ACDS in 2022-23, strengthening ACDS's commitment to participation in global dosimetry audit initiatives.

ACDS has led the International Atomic Energy Agency (IAEA) Dosimetry Audit Network collaboration on film dosimetry intercomparisons, provided lecturing support for IAEA and International Centre for Theoretical Physics (ICTP) training courses on dosimetry auditing and supported the Global Quality Assurance of Radiation Therapy Clinical Trials Harmonization Group (GHG) in a peer-reviewed publication and general meetings.

ACDS was pleased to participate in four publications in peer-reviewed journals in the year, covering diverse areas including magnetic resonance (MR) linear accelerator (linac) dosimetry guidance, motion management in clinical procedures, correction factors for film dosimetry in anthropomorphic phantoms, and a risk analysis for proton dosimetry audits. More detail can be found in the Publications and presentations section.

The ACDS has also continued its work developing audits for emerging radiotherapy techniques such as online adaptive radiotherapy and motion adaptive radiotherapy. These developing audits, and the ACDS current audit program, support Trans-Tasman Radiation Oncology Group (TROG) clinical trial credentialing. Audits of the adaptive process on MR linacs continue to be performed in field trial and motion management audit development remains the highest priority.

The ACDS will continue to support the radiotherapy community with an independent and comprehensive dosimetry audit service to ensure the highest level of quality and patient safety in radiotherapy.

Rhonda Brown
Director ACDS

Gillian Hirth
CEO of ARPANSA

Acknowledgement of Country

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) respectfully acknowledges Australia's Aboriginal and Torres Strait Islander communities and their rich culture and pays respect to their Elders past and present. We acknowledge Aboriginal and Torres Strait Islander peoples as Australia's first peoples and as the Traditional Owners and custodians of the land and water on which we rely.

We recognise and value the ongoing contribution of Aboriginal and Torres Strait Islander peoples and communities to Australian life and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

Contents

ACDS Overview

Our vision

A world leading dosimetry auditing service for the highest level of quality and patient safety in radiation therapy.

Our mission

To guide, support and improve patient safety and radiotherapy service delivery by:

- providing a comprehensive suite of audit modalities covering all common clinical practices
- improving national dosimetry capabilities in clinical treatment delivery
- offering our services to Australian and overseas radiotherapy centres on a fee-for-service basis.

The mission of the ACDS is fully aligned with Key Activity 1 of ARPANSA and its initiative to '*Promote the safe and effective use of medical radiation*'.

Our structure

ACDS, under its Director Rhonda Brown, employs a skilled team of medical physicists, radiation therapists and support staff, who work together to deliver on the ACDS strategic objectives, supporting ARPANSA's strategic direction statement.

ACDS forms an integral part of the Medical Radiations Services Branch (MRSB) at the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) along with the Medical Imaging section and the Primary Standards Dosimetry Laboratory (PSDL), who maintain the Australian primary standard for absorbed dose. The PSDL calibrates the detectors used in ACDS audits against this primary standard, underpinning the quality of the dosimetry audit service.

Research and audit development are aligned with current and emerging clinical practice. The Roger Allison Quality Radiotherapy Centre, opened in March 2019, provides essential access to a modern linear accelerator at ARPANSA premises in Yallambie. This is an essential resource for audit development and will be complemented in 2024 with a second linear accelerator available for PSDL and ACDS. Audit development continues with the Level III 4D motion adaptive audit and MR linac audit processes.

In financial year 2022-23, 99% of Australian and 50% of New Zealand radiation oncology providers, subscribed to the ACDS. Information gathered during audits across the facilities, allows the ACDS to provide consistent data for benchmarking where individual facilities can measure their performance against other radiotherapy facilities with similar resources.

Our staff

Rhonda Brown, Andrew Alves, Sabeena Beveridge, Brendan Healy, Andrew Cole (until January 2023), Fayz Kadeer, Kate Francis, Katherine Collins, Jeremy Supple, Raymond Sun, Sarah Hegarty (from March 2023), Tracey Huang (from May 2023), Daniela D'Antonio, Julie Giblett, Alex Burton

Our associates and external auditors

Since its inception, the ACDS has recognised the value of maintaining close links with current developments in radiation oncology technology and practice. The external auditors pool is one of the ways we achieve this as well as engaging with our institutional memory.

ACDS external auditors are experienced ACDS alumni who are currently working as radiation oncology physics or radiation therapy professionals in Australia or New Zealand and experts in radiation dosimetry currently working at the primary standards laboratories in Australia (PSDL, ARPANSA) or previously in New Zealand (NRL), who are trained in ACDS audit procedures.

These individuals perform audits each year alongside an experienced ACDS audit team member.

The external auditors are subject to the ACDS training and conflict of interest guidelines. The ACDS is mindful of possible conflicts of interest which may arise from using external auditors who are asked to audit other radiation oncology departments while they are currently working in the field. During the audit planning stage, the department is given the opportunity to object to the use of a proposed external auditor.

The present external audit team members are:

Jessica Lye, Johnny Laban, Joerg Lehmann, Francis Gibbons, Duncan Butler, Chris Oliver, Maximilian Hanlon, Maddison Shaw, Stephanie Keehan, Ivan Williams

Our Strategic Plan

The Strategic Plan for the ACDS sets out the strategic objectives over four years and is aligned with ARPANSA's 2-year Corporate Plan, notably ARPANSA's Key Activity 1 and its initiative to '*Promote the safe and effective use of medical radiation*.'

We are confident that the dedicated and highly competent ACDS staff, with the support of ARPANSA's infrastructure and advice from the Clinical Advisory Group, will continue to deliver quality services to the Australian and New Zealand health care system for the benefit of patient safety.

Our strategic objectives

Be recognised as a **global leader** and associated with the **highest standards of quality and safety** in radiotherapy

Be a **comprehensive provider of auditing services** to all Australian and New Zealand radiotherapy centres

Support and collaborate in **high quality research and development** in clinical practice and audit methodologies

Offer **competitive quality audit services** that cover all clinical practices and emerging technologies

Positively **influence the use of radiation in medicine** and have **tangible impact benefitting patient safety**

Our governance

The Clinical Advisory Group

The Clinical Advisory Group (CAG) comprises members across all jurisdictions and practices who have a broad base of professional clinical experience.

The CAG members are appointed by the CEO of ARPANSA and nominated by their professional bodies* to advise the ACDS on development of audit methodologies and immediate clinical interpretation of specific audit outcomes. In addition to this, they review phantom design, measurement techniques and provide advice on relevant treatment techniques for audits, and on what skills, experience, and training is required for ACDS auditing staff.

The CAG meets quarterly and out of session, if necessary, to discuss audit results that could potentially pose a risk to the safety of patients receiving radiation therapy.

The CAG has been an invaluable source of experience and support as they have been since the establishment of the ACDS. It provides high quality and independent governance to the ACDS, ensuring that audit development and strategic direction align with industry needs.

Clinical Advisory Group members

- Lucinda Morris – Chair: RANZCR
- Joerg Lehmann – TROG
- Adam Briggs – ACPSEM
- Louise Nardone – RANZCR
- Andrew Cousins – ACPSEM – New Zealand
- Katrina Woodford – ASMIRT
- Rebecca Thyne – NZIMRT
- Tomas Kron – independent technical expert

* Professional bodies consist of the Royal Australian and New Zealand College of Radiologists (RANZCR), Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM), Trans-Tasman Radiation Oncology Group (TROG), Australian Society of Medical Imaging and Radiation Therapy (ASMIRT) and the New Zealand Institute of Medical Radiation Technology (NZIMRT).

Supporting research and clinical trials

Supporting sound research in radiation therapy is one of the functions of the ACDS, through its strong relationship with the Trans-Tasman Radiation Oncology Group (TROG) and the collaboration with them to develop audits that support credentialling for clinical trials. The ACDS is an observer member of the **Global Quality Assurance of Radiation Therapy Clinical Trials Harmonization Group** (GHG) whose goal it is to promote harmonisation of radiotherapy quality assurance between trial groups globally. ACDS audits may be used towards clinical trial credentialing for TROG trials, see table below, demonstrating that they meet the quality assurance requirements necessary for robust research. It is important to note that audits still in field trial are accepted by TROG as evidence to support that trial participants meet the trial credentialing criteria.

TROG CANCER RESEARCH
www.trog.com.au

TROG Clinical Trials in recruitment or follow-up applicable to ACDS audits

IMRT/VMAT	**SABR** (body)	**SRS** (cranial)
AGITG AG0407GR/TROG 08.08 TOPGEAR	TROG 17.03 LARK	TROG 17.02 OUTRUN
EORTC 1308/TROG 15.02 ROAM	PMC 17/013/TROG 17.05 AZTEC	
ANZ 1601/BIG 16-02 EXPERT	TROG 18.01 NINJA	
TROG 18.06 FIG	CTC 0245/AGITG AG0118PS/TROG 18.04 MASTERPLAN	
ANZUP 1801 DASL-HiCaP	TROG 19.06 DECREASE	
TROG 20.01 CHEST-RT	VCCC/TROG 20.03 AVATAR	
MASC 2101 i-MAT	TROG 21.07 SOCRATES	
ANZGOG1910/2020/CTC0299 ADELE	AGITG TROG 21D RESOLUTE	
	TROG 15.03 FASTRACK II	

ACDS accreditation requirements

The ACDS is an ISO/IEC 17025 accredited testing service which provides dosimetry audits to meet:

- Radiation Oncology Alliance Radiation Oncology Practice Standards (a peak group comprising the four key specialties in radiation oncology and representing their respective organisations RANZCR, ASMIRT, ACPSEM and Cancer Nurses Society of Australia)
- Radiation Oncology Health Program Grants (ROHPG) (Australia) funding conditions
- jurisdictional radiation licensing requirements.

The ACDS forms part of the ARPANSA corporate ISO/IEC 17025 National Association of Testing Authorities (NATA) accreditation. This is a competency-based standard which requires the ACDS, and the six other ARPANSA laboratories, to undertake a rigorous internal and external auditing program, focused on employee competence.

The NATA is the external certification body which performs a surveillance audit and re-assessment audit every 18 months thereafter. These re-assessment audits require the use of an external technical expert in ACDS' field of radiotherapy dosimetry. As ACDS is the peak body in Australia, we use equivalent experts from around the world to perform technical assessments of ACDS staff.

Further information regarding NATA accreditation, the ACDS and the ARPANSA management system can be obtained by contacting our quality manager at qualitymanager@arpansa.gov.au.

ACDS audit services are recognised as meeting the Radiation Oncology Alliance, Radiation Oncology Practice Standards (ROPS) criteria for independent dosimetric comparison/audit.

Global affiliations

International collaboration

Global Harmonization Group

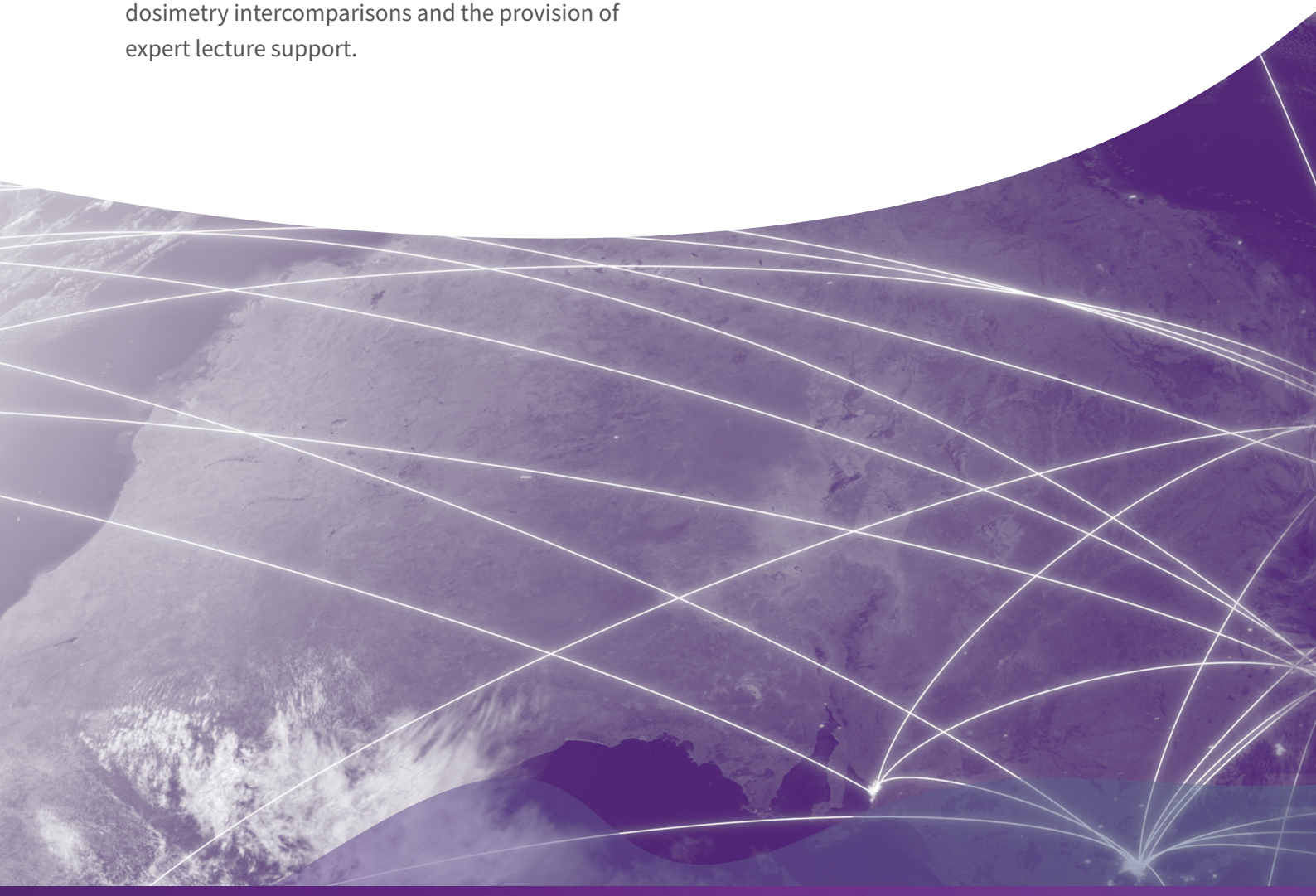
The ACDS is an observer member of the Global Quality Assurance of Radiation Therapy Clinical Trials Harmonization Group (GHG). The group consists of clinical trial quality assurance offices and auditing bodies around the world and aims to harmonise and improve clinical trial quality assurance in radiation therapy worldwide.

International Atomic Energy Agency (IAEA) Dosimetry Audit Network

As a member of IAEA's international Dosimetry Audit Network (DAN), the ACDS continues to play a constructive role in projects such as film dosimetry intercomparisons and the provision of expert lecture support.

Imaging and Radiation Oncology Core (IROC)

The ACDS and IROC Houston QA Center have a memorandum of mutual recognition agreement of dosimetric audit equivalence for the ACDS Level I optically stimulated luminescence dosimeters (OSLD) audits. This agreement recognises the technical equivalence and frequency of both organisations' OSLD mail-out audits. In practice, this means that a facility may provide ACDS Level I OSLD results where there is a requirement for an IROC OSLD audit, such as in a clinical trial. This agreement is maintained by regular intercomparisons of the mail-out audit by the ACDS and IROC.



Stakeholder engagement

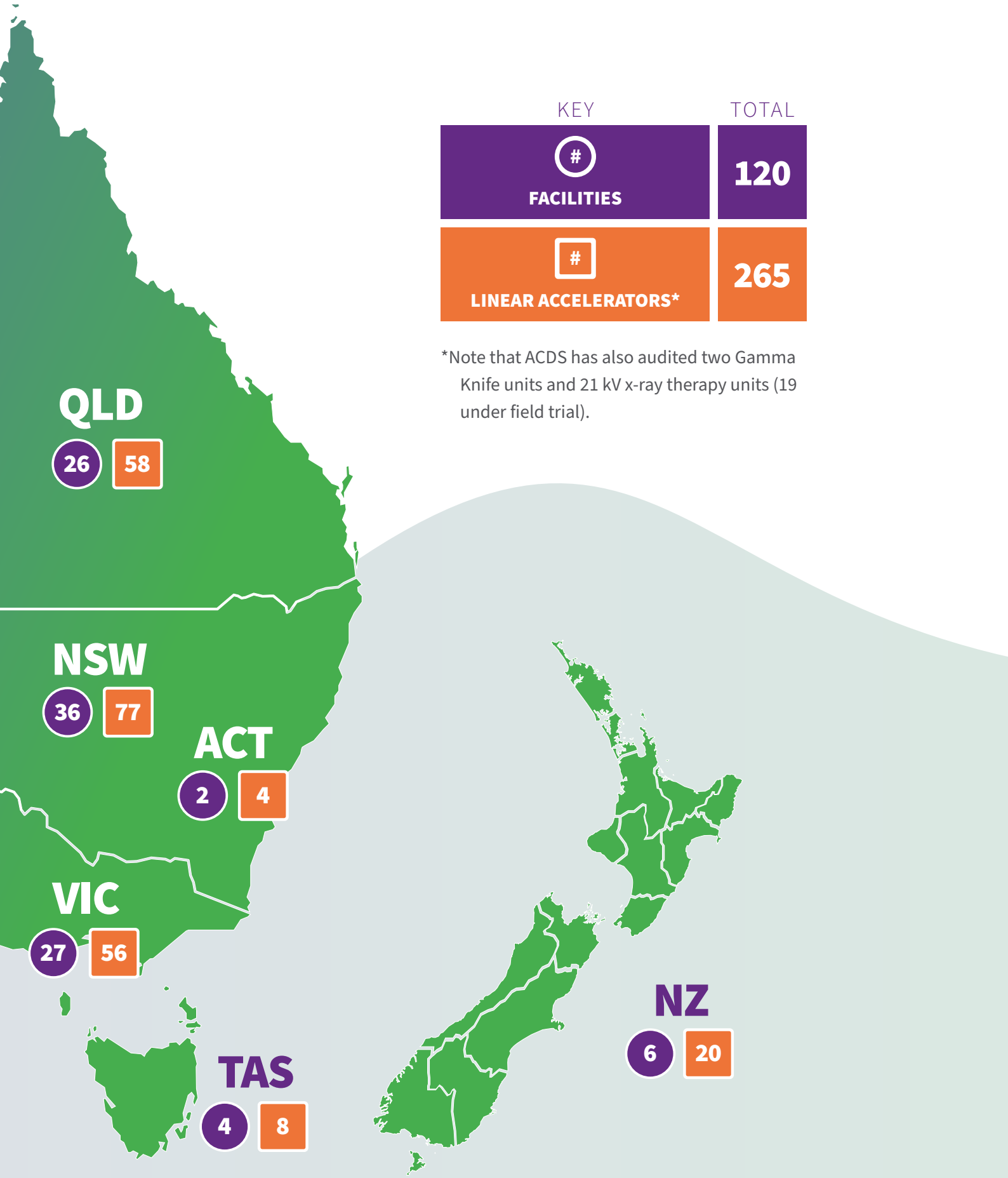
ACDS continues to seek feedback and advice from its Stakeholder Engagement Group (SEG). A successful meeting of SEG was held in March 2023, bringing together in a full day meeting representatives from state and territory radiation regulators, the Commonwealth Department of Health and Aged Care, peak professional bodies, TROG, as well as private and public radiotherapy facilities.

The SEG meeting provided the opportunity for ACDS to present its audit structure and schedule, receive feedback from SEG and horizon-scan in future audit capabilities.

National and international audit coverage

KEY	TOTAL
# FACILITIES	120
# LINEAR ACCELERATORS*	265

*Note that ACDS has also audited two Gamma Knife units and 21 kV x-ray therapy units (19 under field trial).



ACDS 2022–23
by the numbers

Approximately **80,000 patients across Australia** alone receive radiotherapy each year. All benefit from the services of the ACDS.

114 Australian radiotherapy providers subscribed to the ACDS, this covers **245 linacs.**

6 New Zealand radiotherapy facilities subscribed to the ACDS, this covers **20 linacs.**

107 on-site audits including 5 field trials, 9 follow-up audits.

38 Level III audits involving SABR cases.

175 films irradiated and analysed for SABR cases.
103 films irradiated and analysed for SRS cases.

16 film calibrations for SABR and **8 film calibrations** for SRS.

120 linacs covered by **63 facility mail out audits.**

4 peer-reviewed publications, 24 presentations at conferences, meetings and training courses.

Full-time ACDS auditing staff completed on average **24 onsite audits** in **FY2022-23.** External auditors completed **26 onsite audits** in total.

621 flight hours, 383,707 km covered by ACDS staff in Australia and New Zealand air travel.

2 New Zealand road trips in FY2022-23 covering **9 onsite audits** across **6 facilities** and **6 onsite deliveries of ACDS phantoms** to facilities for CT scanning in preparation for Level III audits.

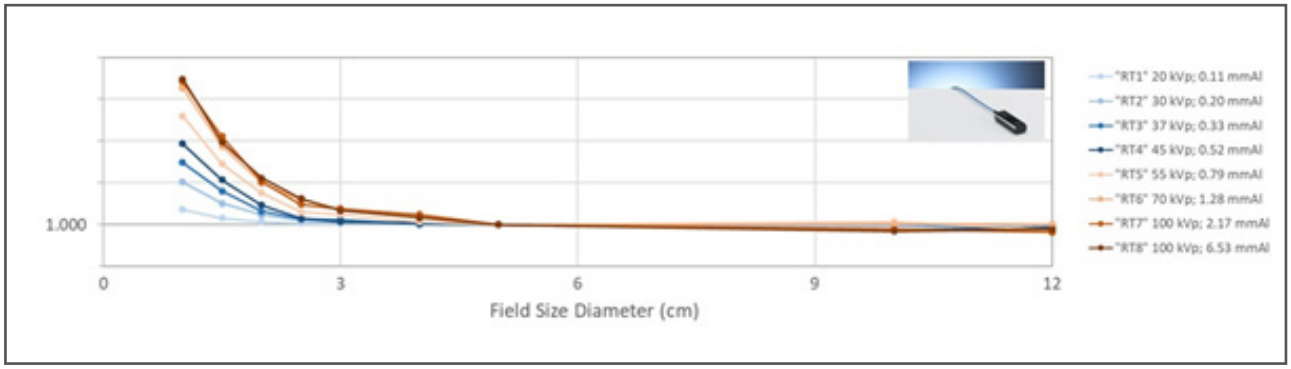
The ACDS Quality Manual consists of **131** documents: **16** work instructions, **3** templates, **37** supplementary, **25** standard operating procedures, **50** forms.

The ACDS maintains **11** PTW 30013 Farmer type chambers, **17** IBA CC13 chambers, **4** PTW Roos chambers, **12** electrometers, **7** microDiamond detectors, **2** microStar ii OSLD readers, **1** EPSOM film scanner, **2** PTW Octavius 1500 MR detector arrays, **3** anthropomorphic lung/abdomen phantoms, **6** digital barometers, **6** digital thermometers, **1** anthropomorphic head phantom. **4,900** OSLDs currently in use.

Audit development and research

Kilovoltage X-ray therapy audits

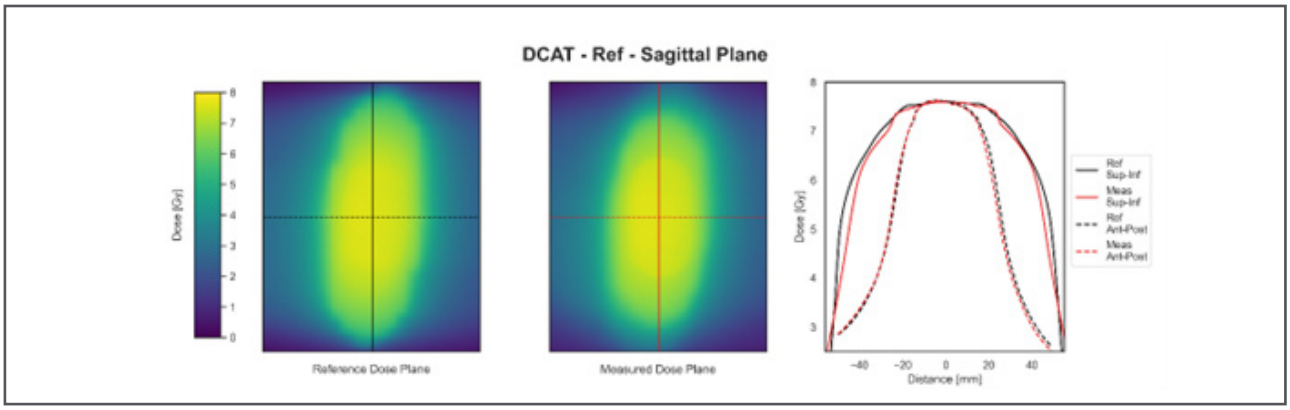
Level Ib audits of kilovoltage x-ray therapy units have been live since 1 July 2022 and these audits can be requested by facilities outside of the regular schedule. The audit involves in-air measurements with calibrated ionisation chambers following the AAPM TG61 protocol. However, the ACDS remains active in ongoing research in kilovoltage x-ray dosimetry. Firstly, field trials of Level I OSLD audits for kilovoltage x-ray therapy units are ongoing. Secondly, the ACDS is active in extending the scope of its audit to the 10-40 kVp energy range. And finally, the ACDS is nearing completion of research in the measurement of stem corrections ($P_{stem,air}$ in AAPM TG1 terminology) for the commonly used ionisation chambers PTW model 23342 and model 23344. Monte-Carlo calculated stem correction factors have been calculated for these chamber designs and validated by measurements on ARPANSA's MEX x-ray unit. The ACDS is preparing to publish the results of the calculations and measurements, with the aim in applying stem corrections to reduce uncertainty in dosimetry measurements for treatment applicators smaller than the reference applicator.



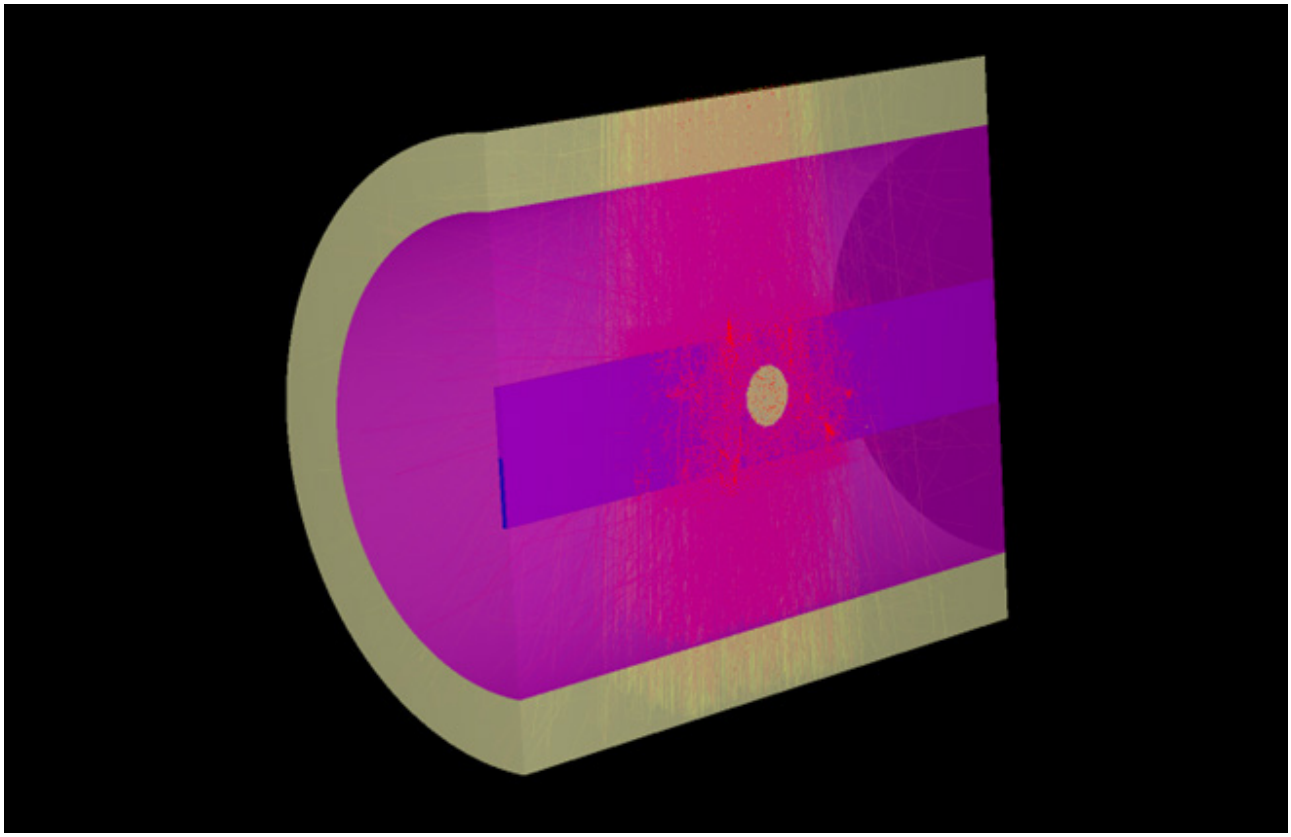
Motion management audit development

The ACDS continued its development of an end-to-end dosimetry audit for respiratory motion management throughout the year. Production of the dedicated audit phantom has experienced several delays but is anticipated to be undergoing commissioning in the first quarter of 2024.

The ACDS has embarked on a research collaboration involving motion management audits with the Imaging and Radiation Oncology Core (IROC) and the Peter MacCallum Cancer Centre (PMCC). A 4D dose accumulation tool was used to simulate audit measurements in the IROC thorax phantom under clinically realistic irradiation conditions, including common planning/delivery errors previously identified by IROC. The tool allowed the dose distribution resulting from irradiating a moving phantom to be explicitly calculated. This allowed the complex relationship between planned and delivered doses for passive motion management to be examined and has led to the development of novel scoring approaches which will be implemented in the prospective ACDS dosimetry audit. A research manuscript is being prepared for expected publication in 2024.



As the dosimetry phantom nears completion, measurement correction factors are being modelled using Monte Carlo simulation in EGSnrc. This will enable doses measured with detectors calibrated in terms of dose-to-water to be accurately compared to dose-to-medium calculations. This work is ongoing and the new correction factors will be tested during commissioning of the phantom.



Audit development and research

Data mining of the Australia - New Zealand (ANZ) Level II and III Data Sets

In February 2023, the ACDS started research project work with Melbourne University's Data Science program as an industry partner. The project ended in November 2023, where the student groups submitted their final reports and providing the ACDS with their analytical tools and software applications created specifically for this project.

Two groups of MSc students were assigned to data mine the aggregated audit results in the ACDS Australia and New Zealand Dataset (ANZ DS) – the aim was to provide the ACDS with insights into groupings and trends within the ANZ DS. A close examination of the different treatment planning system (TPS) algorithms with audit results was also being analysed. Statistical modelling and machine learning techniques were used to examine the data and develop predictive features that can be used by the ACDS to improve audit analysis and performance.

Film management and inventory tracking

Gafchromic film plays an important role in SABR and SRS audits and requires several supporting operations to be used effectively. Known as the film management program, these processes, such as film ordering, inventory tracking, calibration scheduling, and audit film preparation and analysis are administered separately by the onsite ACDS Specialist Dosimetrist.

To streamline this program, the ACDS Software Specialist, the Specialist Dosimetrist, and the University of Melbourne industry partner program are working in collaboration to develop a software application and database solution called FRUIT (Film Register Using Inventory Tracking).

FRUIT's clean user interface will provide the status of all current film audits and calibration schedules at-a-glance. Additionally, the program's associated audit and film inventory databases will provide a central location for all the information needed for audit film processing and automatic tracking of available film.

Incorporation of FRUIT in audit procedures will enable offsite staff to assist with film operations, improve allocation and use of film resources, and consolidate all current film management activities.

Film QC software

The ACDS has continued developing quality assurance (QA) procedures and quality control (QC) metrics in the film dosimetry process used in Level III audits. While QC metrics are currently in place for both the fit of the calibration curve and the check film scale factor (a factor calculated using pieces of film irradiated with a known dose as part of the audit), no such checks have been applied to unirradiated film. A new QC process, known as FUCHSIA (Film Uniformity CHeck Sequential to Irradiation and Audits) is being developed to ensure that unirradiated film is acceptable prior to use. The purpose of this is to minimise audit results being influence by errors in the film, thus increasing the confidence in the film dosimetry process. All films, those used for the calibration curve and the audit films, are checked in this process.

A scientific paper is in development correlating metrics on the unirradiated and irradiated films and how they related to the final audit results. The aim is for all the film QC metrics to be calculated in the context of impact on audit results. It will also reveal the key points in the film dosimetry process that have the potential to significantly alter the outcome.

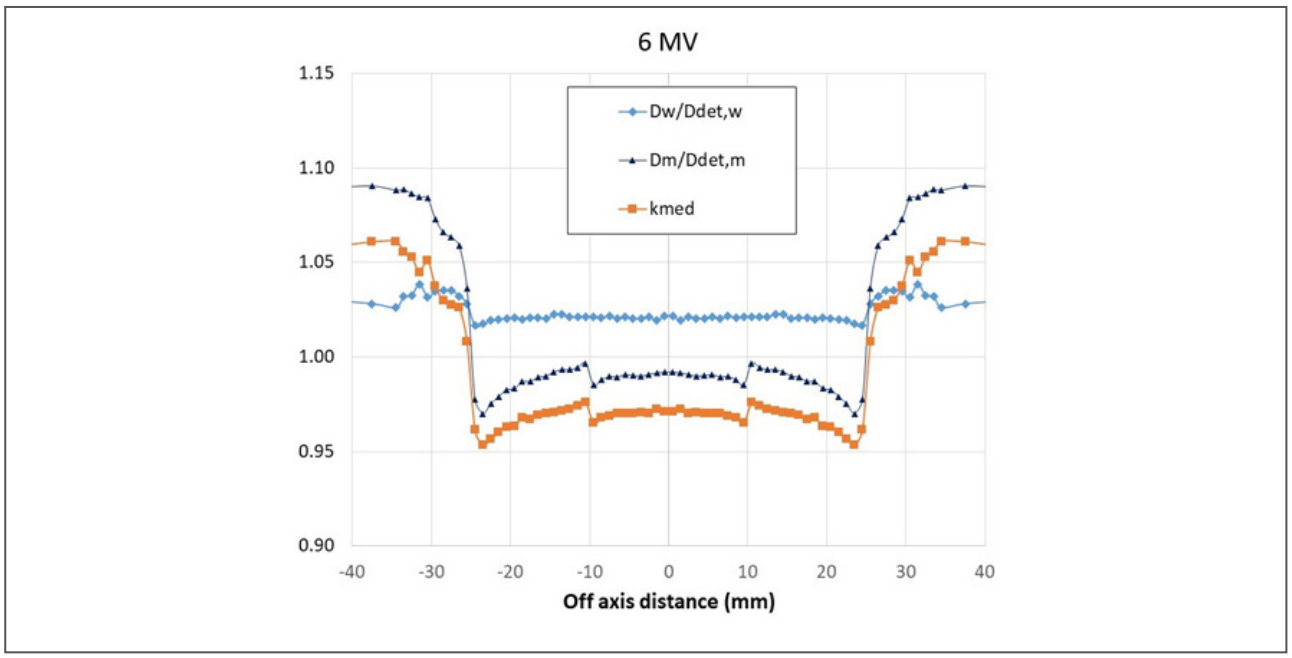
Audit development and research

Particle therapy

The ACDS continues to monitor the development of the Australian Bragg Centre for Proton Therapy and Research in Adelaide and other potential particle therapy installations in Australia. As a part of the scoping work for proton dosimetry audits, the ACDS has participated in a GHG review of harmonisation in Proton vs Photon QA, to ensure that developed procedures are in line with international best practice. ACDS staff also attended the 6th Annual National Particle Therapy Symposium at Westmead Hospital 24-25 November 2022 to learn of current approaches in particle therapy and associated dosimetry.

Correction factors for film dosimetry in tissue-substitute materials

ACDS strives to not only develop appropriate audit techniques for modern clinical practice but also to contribute to advances in fundamental radiation dosimetry. ACDS has developed corrections for film dosimetry in tissue substitutes for lung, bone and soft tissue and published its findings in two peer-reviewed publications, namely Shaw et al 2021 and Shaw et al 2023. These dosimetric corrections are applied in the ACDS Level III SABR audit cases for spine and lung treatments. In essence, the Monte-Carlo calculated correction factors modify the dose-to-water calibration of the radiochromic film with a tissue-specific dose calibration for the film in place within the ACDS anthropomorphic phantom. The methodology employed to derive these correction factors can be applied not only to ACDS audits, but also to other dosimetric applications involving the same tissue substitutes.



Case studies and key findings

Sharing key findings and making recommendations for facilities provides valuable insight into ways of strengthening the quality assurance practices involved in radiotherapy planning and delivery. This in turn has a positive tangible impact on patient safety.

Audit outcomes and the role of the Clinical Advisory Group

Deidentified Out of Tolerance audit results are referred to the Clinical Advisory Group (CAG) as the dose difference may impact patient outcomes. In their review, the CAG will evaluate for clinical impact, advise on follow up and advise on appropriate recommendations. The CAG reviewed 14 Out of Tolerance (OT) audit cases from 14 facilities in FY 2022-23. Of these, 2 cases from 2 facilities were reassigned due to audit artefacts. As per standard practice, the Level I OT case was designated as unconfirmed and immediately followed up with an onsite Level Ib audit which returned Pass (Optimal Level). 11 facilities were offered repeat audits as follow up. Causes of Out of Tolerance cases can be categorised as related to image guidance (2 cases), beam model optimisation (2 cases), clinical process compliance (3 cases) while 4 cases remained under investigation on 30 June 2023.

Level I 63 audits	**No. OT Cases**	**Level II** 29 audits	**No. OT Cases**	**Level III** 39 audits 9 SRS	**No. OT Cases**
Photons FFF	1*	VMAT	1	IMRT	1
		VMAT FFF	1	SABR Lung	3
				SABR Soft Tissue	1
				SABR Spine	1
				SRS MR Multi	1
				SRS Complex Multi	4

*Level 1 OT results are designated as unconfirmed and immediately followed up with an onsite Level Ib audit

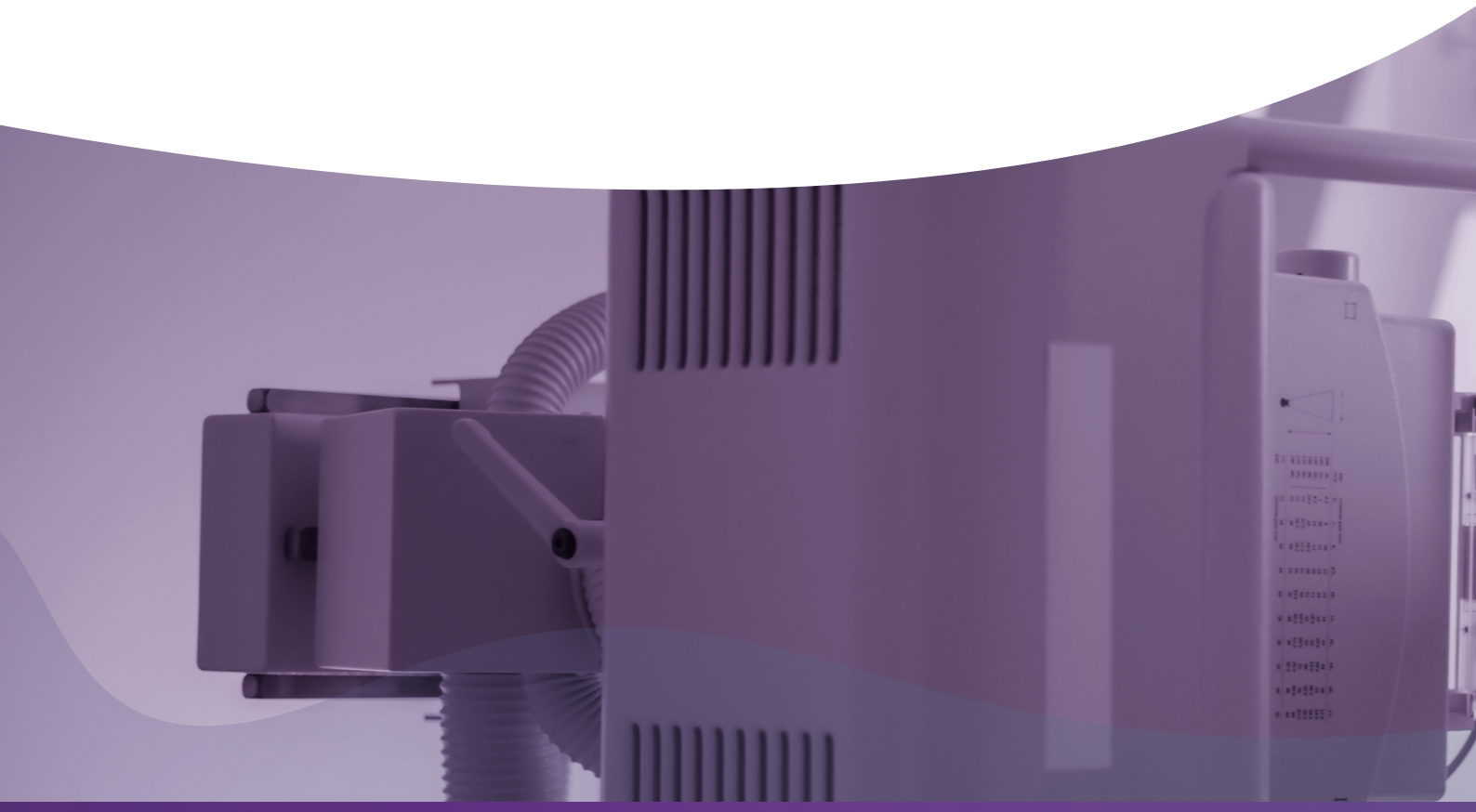
Case studies and key findings

Clinical procedure compliance

ACDS observes instances of poor audit performance related to lack of compliance with the audited facility's clinical procedures in producing audit plans for delivery on the day of the audit, particularly in the case of the end-to-end Level III audits. Examples include:

- Not including the treatment couch in treatment plans,
- Setting of plan parameter values outside the range of standard clinical practice, for example the aperture shape controller parameter in Eclipse, the treat margin parameter in RayStation, and the minimum distance between PTV and PRV (i.e. target and organ-at-risk),
- Submission of plans which do not meet the prescribed dose constraints as per the ACDS instructions,
- Misalignment in the registration of ACDS structure set to the facility's CT scan of the ACDS anthropomorphic phantom,
- Submission of plans with CT scan resolution or dose grid resolution not consistent with standard clinical practice.

As part of its pre-audit checking procedures of submitted treatment plans, ACDS attempts to identify as many of these issues as possible. While it is the responsibility of the audited facility to submit treatment plans consistent with its clinical procedures, ACDS acknowledges that it has a role to play in identifying issues with treatment plans as part of the audit process. ACDS is investigating the use of the Elekta ProKnow software package and in-house software to further assist in thorough and efficient review of treatment plans prior to audit.



Submission of non-clinical cases

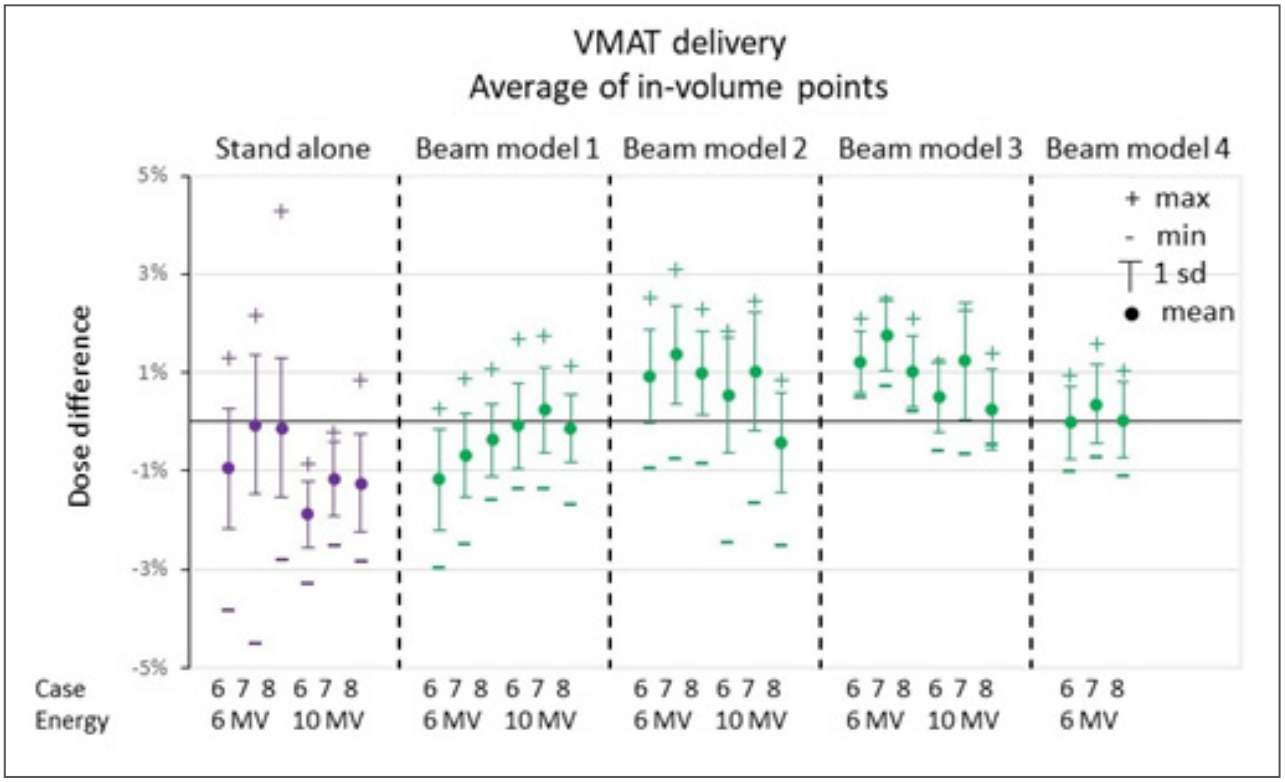
The ACDS observes, and notes as a trend, that radiotherapy facilities have submitted treatment plans for audit based on treatment techniques which are not currently clinically released. However, the intention of the dosimetry audit service is to audit only those techniques in current clinical release, rather than form part of the commissioning process for a particular modality or technique. By way of example, the Level Ib audit is performed on a new linear accelerator only after commissioning is complete. ACDS acknowledges the desire of facilities to use its dosimetry audit service as a testing opportunity for techniques in development. The ACDS's position is that it will only measure and score submitted plans for techniques that have completed commissioning and are in clinical release or are ready for clinical release. On case-by-case basis, ACDS will consider requests for measurement of non-clinical techniques considering need and logistics.

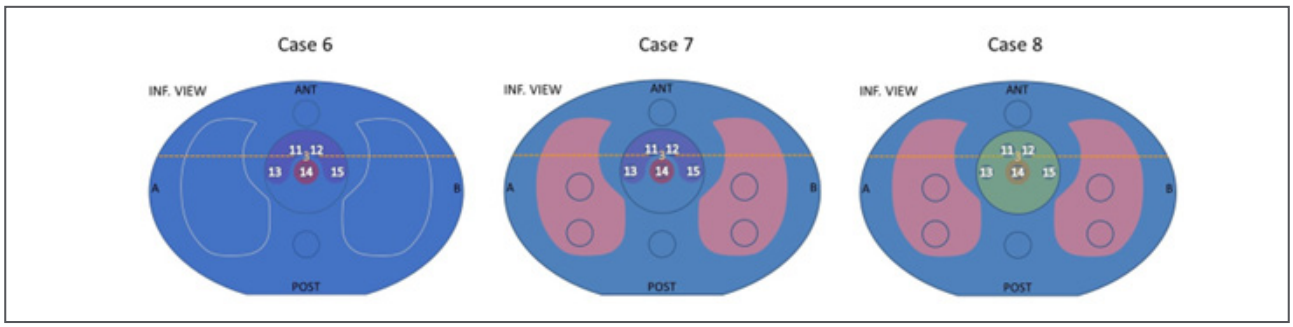
Case studies and key findings

Performance of networks using a common beam model

Since its inception, ACDS has taken the position that it will perform regular dosimetry audits on each individual facility within a network of facilities. The alternative would be to audit only one facility of a network and assume that the common treatment planning system, common beam model, common treatment delivery system configuration and common procedures imply that audit performance would be uniform across all facilities of the network.

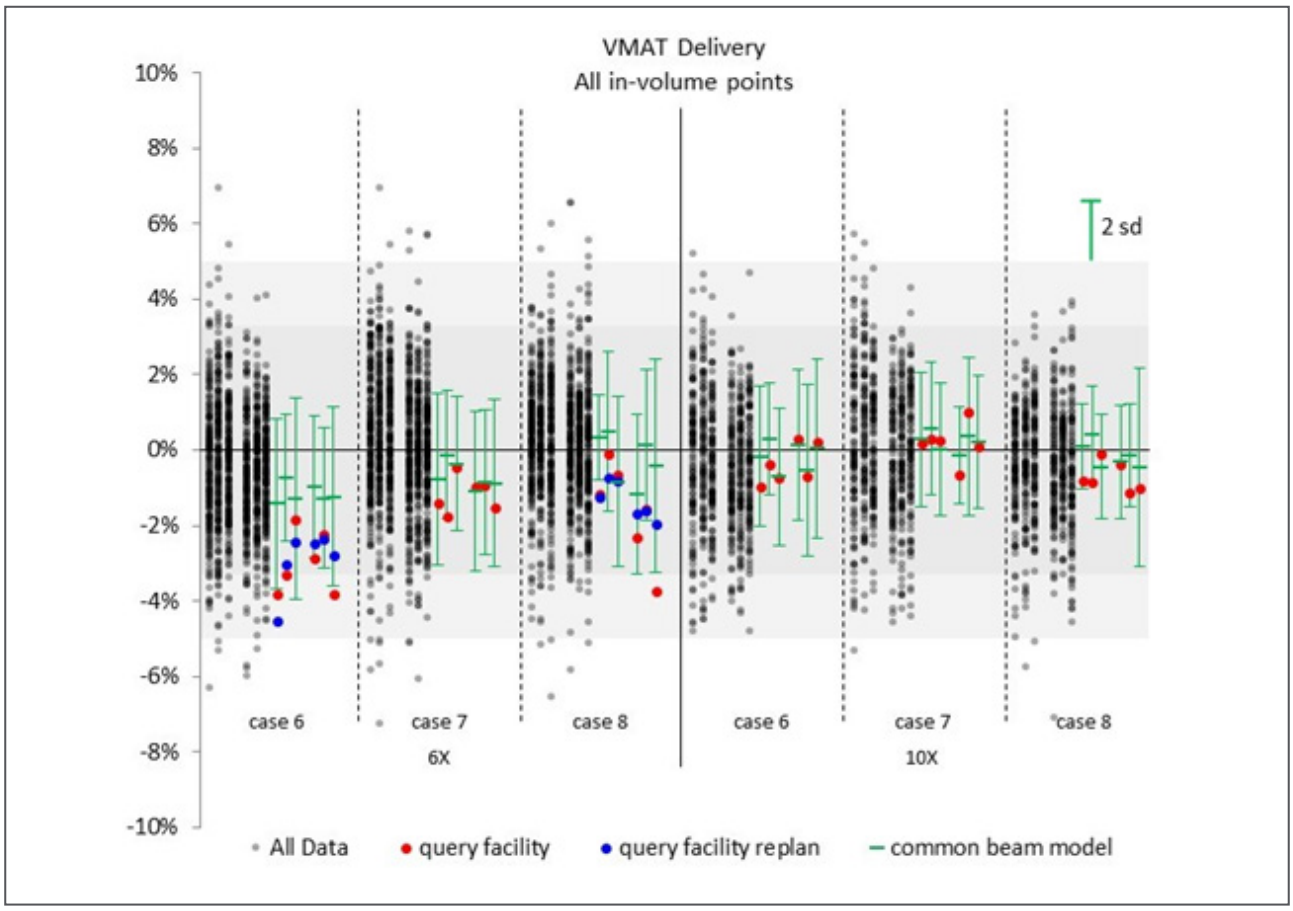
Aggregated results from ACDS audits of networked and non-networked (standalone) facilities give the opportunity to observe trends in the audit performance of networks. The Volumetric Modulated Arc Therapy (VMAT) modality of the end-to-end Level III audit (cases 6, 7 and 8, pictured to the right) has been selected for review because it is widely used across many facilities and the ACDS procedure for dosimetry measurements of the VMAT cases has not had any recent modifications. In the figure below the audit performance is charted (ACDS output-corrected measurement vs TPS planned) for a series of unrelated standalone facilities and for networks (both public and private) operating a common beam model with a common treatment delivery system. Note that output correction of the ACDS measurement means that the ACDS measurements have been corrected by the ACDS measurement of the prescription point in the reference Case 1 to account for offsets in base dosimetry or daily linac output variation. Networks with a common beam model can produce a more consistent audit result than unrelated standalone facilities, particularly for the 6 MV modality in these selected VMAT cases. However, even amongst networks, there is spread of audit results including outliers.





A recent case study, charted in the figure below, demonstrates an example of an outlier result at a particular facility within a network. Again, case 6, 7 and 8 results are presented and the ACDS measurements are output corrected, however all in-volume points are presented rather than the in-volume average. For 10 MV, there is good agreement between planned and measured dose with the average dose variation for multiple facilities close to 0% across three audit cases. However, for 6 MV there is an average offset in dose variation of 1-2% for the common beam model, especially for case 6 and 7. A single query facility demonstrated even further offset when compared to other machines on the same beam model. Performing a re-plan by adjusting the plan modulation did not improve the performance.

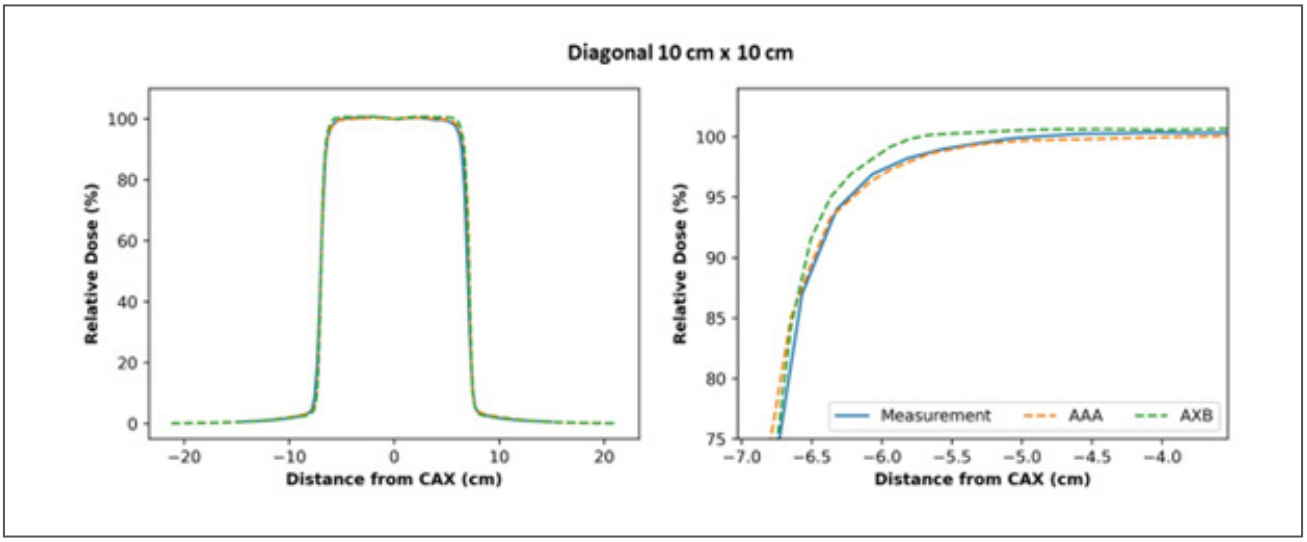
ACDS infers that its approach of auditing every facility in a network is valid and will continue that approach.



Case studies and key findings

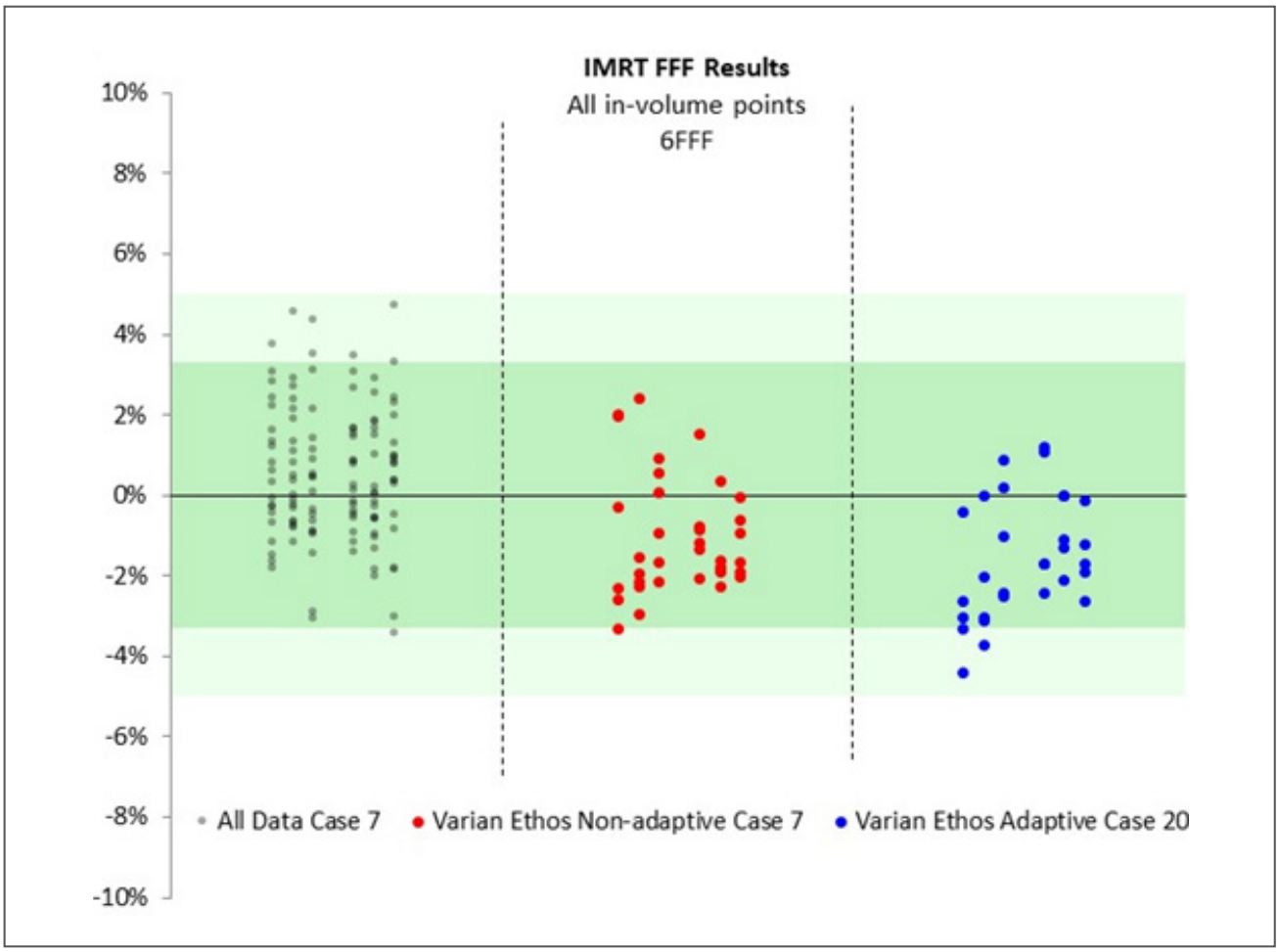
Trends in off-axis beam modelling for the Varian Acuros XB algorithm

Analysis of the results of more than 200 Level II audits offers the opportunity to identify trends in treatment planning system capability. As reported in last year's ACDS review, it has been observed for the Acuros XB algorithm that there is a systematic overestimation of dose towards the corners (diagonals) of open 10 x 10 cm2 fields. The same trend is not observed for open 20 x 20 cm^2 fields. During the year, ACDS received facility data in the form of measured beam profiles and TPS calculated profiles in order to confirm the ACDS findings. Preliminary analysis of data from facilities indicate consistency with ACDS results however further datasets from different facilities are required.



Online adaptive audits

In the year, online adaptive audits were live for Varian Ethos linacs and remained in field trial for MR-linacs. Case 20 tests positional shifts as well as changes in target shape and is relevant for the Varian Ethos linac. The original C-shape structure is required to be redrawn to match the Case 7 structure provided in the ACDS fusion dataset. The treatment needs to be adapted with full multi-leaf collimator (MLC) and dose optimisation, and the plan protocol variations are checked prior to the treatment. Audit results demonstrate that Varian Ethos treatment machines have similar results (within tolerance) to standard linac treatments for case 7, while case 20 results are comparable to case 7 results and within tolerance.



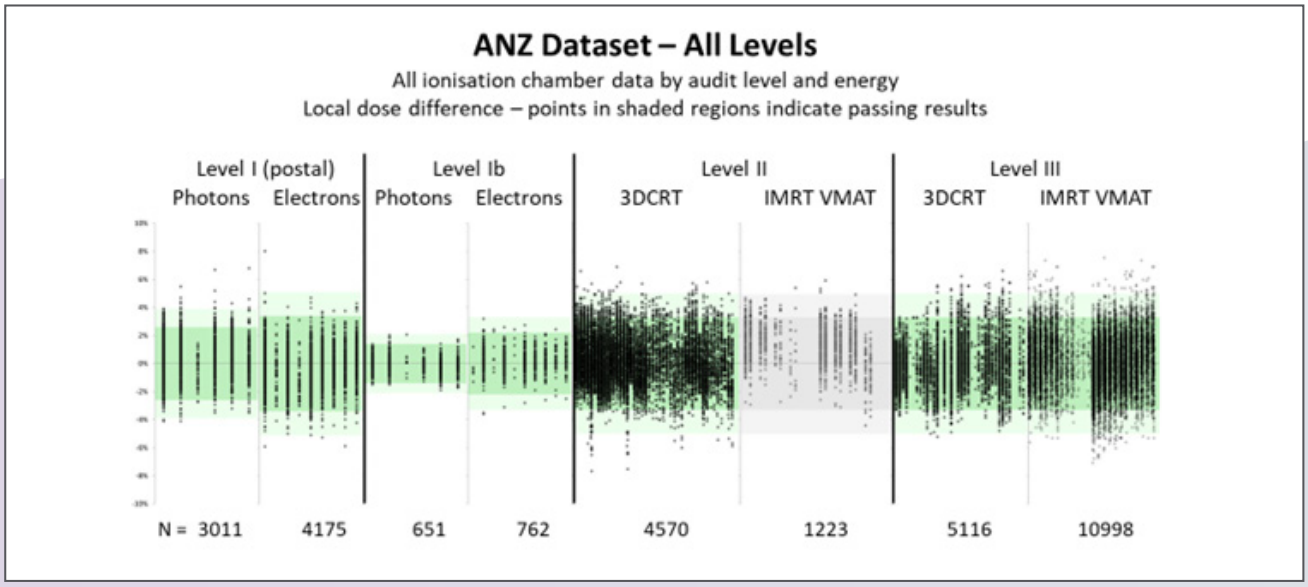
The ANZ Dataset

The ACDS keeps a database of all audit results in the ANZ Dataset, the aggregation of the results from more than 1,200 audits performed by the ACDS in more than 100 facilities since 2012 on all commonly available treatment planning systems and treatment machines across Australia and New Zealand. The ionisation chamber measurements alone total over 30,000 data points, see below.

The ability to identify trends and make personalised comparisons such as between linac types/vendors or treatment planning system algorithm implementations with meaningful deductions relies on a large cohort of facilities and different beam models. This large bank of anonymised data is used for:

- Benchmarking an audited radiation oncology facility's results, forming the basis for identification of trends. Personalised comparison charts are presented in the audit reports supplied to the audited facility.
- Diagnosis of suboptimal results via comparison of results against all data or against other radiotherapy facilities with similar resources. Out of Tolerance results are anonymised and reviewed against the ANZ Dataset by the Clinical Advisory Group.
- Benchmarking of aggregated, anonymised data for case studies presented in annual reports (ACDS Year in Review), peer-reviewed publications and conference presentations.
- Publication of audit data in peer-reviewed journals highlighting specific features of treatment planning system algorithm implementations, including validating correction factors to increase accuracy of in-phantom dose measurements.
- Quality control of the audit service performance. The distribution of actual results is reviewed annually by the Clinical Advisory Group in context of the expected distribution.

A detailed summary of the ANZ data for each audit level is publicly available on our website by searching "ACDS Australia and New Zealand datasets" or visiting arpansa.gov.au/our-services/testing-and-calibration/calibration/australian-clinical-dosimetry-service/datasets.



Publications

Shaw M, Lye J, Alves A, Lehmann J, Sanagou M, Geso M, Brown R (2023) 'Measuring dose in lung identifies peripheral tumour dose inaccuracy in SBRT audit', Physica Medica, 112:102632 https://doi.org/10.1016/j.ejmp.2023.102632

Taylor P, Miles E, Hoffmann L, Kelly S, Kry S, Møller D, Palmans H, Akbarov K, Aznar M, Clementel E, Corning C, Effeney R, Healy B, Moore A, Nakamura M, Patel S, Shaw M, Stock M, Lehmann J, Clark C (2023) 'Prioritizing clinical trial quality assurance for photons and protons: A failure modes and effects analysis (FMEA) comparison', Radiotherapy and Oncology, 182:109494 https://doi.org/10.1016/j.radonc.2023.109494

Begg J, Jelen U, Moutrie Z, Oliver C, Holloway L, Brown R (2023) 'ACPSEM position paper: dosimetry for magnetic resonance imaging linear accelerators', Physical and Engineering Sciences in Medicine, 46:1-17 https://doi.org/10.1007/s13246-023-01223-w

Burton A, Beveridge S, Hardcastle N, Lye J, Sanagou M, Franich R (2022) 'Adoption of respiratory motion management in radiation therapy', Physics and Imaging in Radiation Oncology, 24:21-29 https://doi.org/10.1016/j.phro.2022.09.003 *

* the second most downloaded paper in PhiRO in 2022

Presentations

TROG annual scientific meeting
19-22 June 2023 Adeliade
Healy, B. *Common mechanisms for reduced audit performance – ACDS update*

National physical laboratory
17 May 2023 London
Brown, R. *ACDS organisational structure and audit program overview*

Global Haromінization Group meeting
11 May 2023 Vienna
Brown, R. *ACDS update*

IAEA SSDL network meeting
29-31 May 2023 Vienna
Healy, B. *TRS-398 update: Formalism for low- and medium-energy X ray beams - Chapters 8 and 9*

Healy, B. *Activities at the ARPANSA dosimetry laboratories and regulatory requirements in Australia for radiation dosimetry*

Elekta ANZ user meeting
24-26 March 2023 Sydney
Francis, K. *Dosimetry audits of the Elekta Unity MR linac*

AusMRinRT conference
7-9 December 2022 Noosa
Burton, A. *The Current Status of MR-linac dosimetry audits*

Joint IAEA-ICTP Workshop on radiotherapy dosimetry audit methodologies
28 November - 2 December 2022 Trieste
Alves, A. *ACDS experience in dosimetry audits - A case study*

Alves, A. *Dosimetry audit types (onsite, remote, virtual)*

Alves, A. *Film dosimetry*

Alves, A. *Other detectors*

Alves, A. *IMRT audits and reporting of audit results*

Alves, A. *ISO/IEC 1725 General requirements for the competence of testing and calibration laboratories*

Alves, A. *Reporting of audit results*

SRS symposium
17 November 2022 Melbourne
Alves, A. *Overview of the ACDS SRS audit – where can we all improve?*

EPSM 2022
14-16 November 2022 Adelaide
Brown, R. *Auditing dosimetry for safety's sake - an update from the ACDS*

Healy, B. *Update on IAEA RAS6101 Regional Project*

Supple, J. *Trend in off-axis beam modelling observed for AcurosXB in ANZ audit data*

RANZCR annual scientific meeting
27-30 October 2022 Adelaide
Morris, L. *Clinical impact and risk mitigation of the Australian Clinical Dosimetry Service*

IAEA RAS6101 regional training course on quality management and quality assurance in radiotherapy medical physics
12 September - 14 October 2022 Virtual
Alves, A. *Auditing advanced techniques including IMRT*

Alves, A. *Auditing SRS techniques*

Alves, A. *Uncertainties of measurements according to TRS-398 and TRS-483*

Alves, A. *Uncertainty estimation of doses and dose comparisons during dosimetric audits*

ACPSEM NSW/ACT branch workshop on motion management in external beam radiation therapy
27-28 July 2022 Virtual
Burton, A. *Motion management in a dosimetry audit - patterns of use of MM in Australia/New Zealand*

Professional development and feedback

ACDS audits continue to be endorsed as a CPD activity by ASMIRT. CPD credits are claimable for both planning and treatment radiation therapists for both Level II and Level III audits.

ACDS audits are endorsed by the ACPSEM as a CPD activity. This falls under category 3 'Measuring outcomes' activity B 'Clinical Audits'. Audit participation certificates have been issued to medical physicists for audits performed since 1 January 2022.

Stakeholder feedback is essential to the cycle of ACDS audit development and review. It ensures that audits continue to meet the needs of radiation therapy departments and contribute to the safety of treatment planning and delivery. The ACDS continues to actively seek feedback on both their products and service delivery.

Our post-audit feedback surveys have been redeveloped so that information is collected relative to specific professional clinical groups. This allows us to tailor our changes in practice and ensure that we provide a service reflecting the needs of our consumers. Surveys have been constructed to be as time sensitive as possible.

All feedback is seen as an Opportunity for Improvement (OFI) and all OFIs are discussed quarterly at ARPANSA quality meetings or sooner when necessary. As well as informal feedback and post-audit surveys, the formal review process, developed in consultation with the CAG, is accessible via the ARPANSA website.

If a formal review is required, the facility representative is encouraged to discuss any issues or concerns with the director of the ACDS or the Chief Medical Radiation Scientist in the first instance, with the aim of a resolution via email: acds@arpansa.gov.au or phone: +61 3 9433 2220.

Alternatively, or in addition to this, there is the opportunity to either:

- request a further audit review
- dispute a review response by CAG
- provide feedback or a complaint.

Visit the feedback and review webform on our website at arpansa.gov.au/acds-feedback.

Glossary

Term	Abbreviation	Definition
Field trial audit		An audit at preclinical development stage.
Flattening filter free	FFF	A photon beam from a linear accelerator generated without a flattening filter to provide a higher dose rate than a flattened beam.
Intensity modulated radiotherapy	IMRT	A radiotherapy technique involving the use of non-uniform intensity beams to provide the required dose distribution, allowing conformation to target tissue and inhomogeneous dose distributions.
Kilovoltage x-ray reference dosimetry		Calibration of kilovoltage x-ray therapy unit beams under standard reference conditions.
Level I audit		Reference dosimetry for photon and electron beams with passive detectors.
Level Ib audit		Reference dosimetry for photon and electron beams with ionisation chambers.
Level II audit		Array dose measurements in a slab phantom to test treatment planning system performance.
Level III audit		End to end testing with an anthropomorphic phantom and embedded dosimeters.
Live audit		A scored audit part of the current audit program including levels I, Ib, II and III audits.
MR linac		Medical linear accelerator with magnetic resonance imaging capability.

Term	Abbreviation	Definition
Planning target volume	PTV	The volume encompassing the clinical tumour volume with an appropriate geometric margin.
Planning organ-at-risk volume	PRV	The volume encompassing an organ-at-risk with an appropriate geometric margin.
Reference dosimetry		Calibration of linear accelerator photon and electron beams under standard reference conditions.
Stereotactic ablative body radiotherapy	SABR	A radiotherapy technique to precisely deliver radiation dose in a small number of fractions to tumours in the body (except the brain).
Stereotactic radiosurgery	SRS	A radiotherapy technique to precisely deliver radiation dose in a single fraction, or a small number of fractions, to tumours in the brain.
Three-dimensional conformal radiotherapy	3DCRT	Radiotherapy treatments based on 3-D image data with several unmodulated treatment fields shaped to treat only the target tissue.
Treatment planning system	TPS	Computer system to generate radiotherapy treatment plans from 3D patient datasets.
Volumetric modulated arc therapy	VMAT	A form of intensity modulated radiotherapy in which the linear accelerator gantry rotates around the patient while the beam intensity and shape are modulated.

Australian Clinical Dosimetry Service

Australian Radiation Protection and Nuclear Safety Agency

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